

# Small-Scale & Residential Fuel Cells

**LOGANEnergy**

The Wise Power Choice

Premium Power  
Critical Load  
Management  
Combined Power and  
Heat

Project Design,  
Installation, Finance, &  
Customer Support

Clean...Quiet...Reliable  
Fuel Cell Energy Service

Presenter: Sam Logan, Jr.  
[www.loganenergy.com](http://www.loganenergy.com)

## “Clean, Quiet, and Reliable Fuel Cell Power.....At Home”!

### Product Development Status

1. **Plug Power** ... Plug Power & GE formed a partnership in 1998 to market and sell Plug Power's 7kW PEM residential fuel cell power plant. GE retained world-wide distribution rights. Plug Power tested its 7 kilowatt prototype at a home in Latham, NY on its. Used bottled hydrogen since the natural gas reformer is not available yet. 500 “Beta” test units in the market in 2000 for 2001 introduction of commercial units. GE has completed construction of new 50,000 square foot facility capable of manufacturing 15,000 units per year. [www.gemicrogen.com](http://www.gemicrogen.com)

**2. Avista Labs...** Spokane, WA...Developing a 5 kW PEM fuel cell for residential and small commercial applications. Developing a reformer to run fuel cell on natural gas. Unique fuel cell design permits removal and replacement of cell stack subsections without disabling unit. Patented "Hot Swap" power cell cartridges.  
[www.avistalabs.com](http://www.avistalabs.com)

**3. Northwest Power Systems...** Bend, Oregon...Manufactures small fuel processors and integrated their natural gas reformer with a 5 kW PEM manufactured by Oronzio de Nora in Italy to provide power to a home in Bend in 1988. Delivered a test model to Sandia Labs in 1999 for evaluation. Plans to deliver one hundred methanol powered units to Bonneville Power Authority for testing through 2000. Natural gas reformer will be ready for testing with Power Plant in September 2000. [www.northwestpower.com](http://www.northwestpower.com)

**4. Dais Analytic Power...** Boston, MA... Wide ranging fuel cell applications research with DOE and DOD grants since 1984. Developed a 3 kW “Residential Power Generator” (RPG-3K) in 1998. Combines floating battery pack to meet all residential power requirements. Ten additional units produced in 1999 for further testing. Plans to produce 15,000 units in first year of commercialization...2001-2002. [www.daisanalytic.com](http://www.daisanalytic.com)

**5. IFC Corp...**Currently only manufacturer of a commercial fuel cell power plant with 200+ deliveries and over 3,000,000 fleet-wide operating hours-the PC25C, a 200kW phosphoric acid fuel cell power plant for commercial and industrial applications. Developing small scale 7-10kW PEM (combined heat and power) for residential/commercial market... scalable up to 75kw with Toshiba and Carrier Partners. IFC Produces 12 kW fuel cells for NASA space shuttles. [www.internationalfuelcells.com](http://www.internationalfuelcells.com)

**6. Energy Partners...** South Florida independent developer with over fifteen years of product research. Will introduce pre-commercial 3kW unit in second half of 2001. Will be use natural gas fuel. Manufacturing focus on product simplicity and cost control.  
[www.energypartners.net](http://www.energypartners.net)

**7. H-Power...** Beta testing 4.5kW co-gen concept with propane and natural gas fuel choices. Will offer up to 10kW peaking performance with battery pack, and grid-independent option with later units. Commercial units targeted for 4-5 year cell stack life. Anticipates 75% electric plus thermal efficiency. [www.hpower.com](http://www.hpower.com)

## Fuel Cell Technology Benefits

### Key Points For Marketplace...Discussion

- High conversion efficiency of fuel to power and heat.
- Very Few Moving Parts, Low Maintenance.
- Fuel Cell System can be sized to accommodate different capacity needs. Flexible siting.
- Environmentally attractive energy service due to low emissions. Reliable, clean, and quiet. “Green Power”!
- Electrochemical conversion process, dynamic power response,
- Few moving parts...means low maintenance and operating costs.
- Clean “Noise Free” service for power sensitive equipment.
- Power conditioning consistent with CBEMA design criteria for small commercial applications.

## Residential Markets

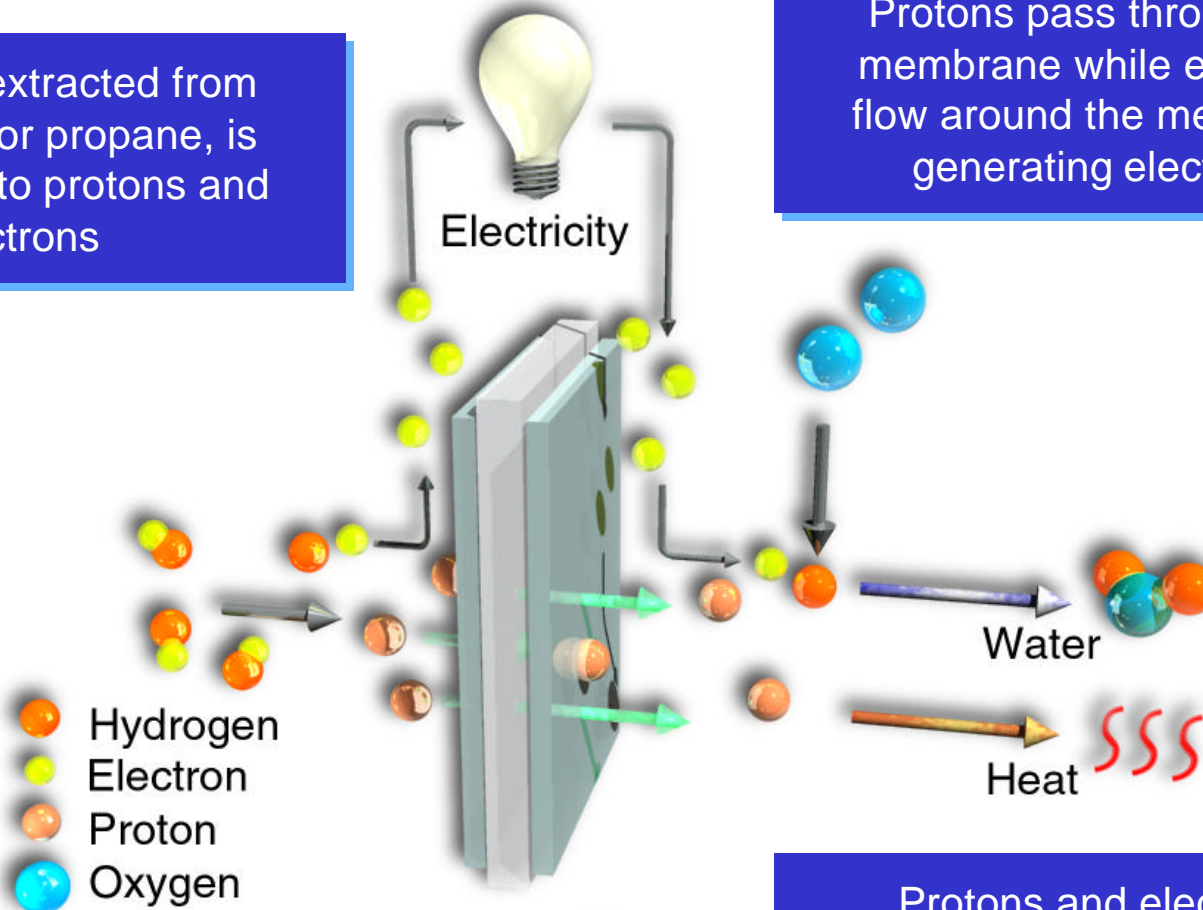
### Key Consumer Issues

- Displaced energy cost equal to or lower than conventional...
- Same or improved service performance...voltage, current, etc...
- Same or improved reliability as utility grid-connected service...
- Grid Parallel or Grid Independent, transfer switch, “0” power export...
- Volume and footprint equivalent to residential HVAC systems...
- Low-emissions, green signature...
- Compliance with building, equipment and safety codes...
- Low noise levels...
- AGA, UL certifications...
- **RELIABILITY !!!**

## Single PEM Cell Schematic

Hydrogen, extracted from natural gas or propane, is separated into protons and electrons

Protons pass through the membrane while electrons flow around the membrane generating electricity



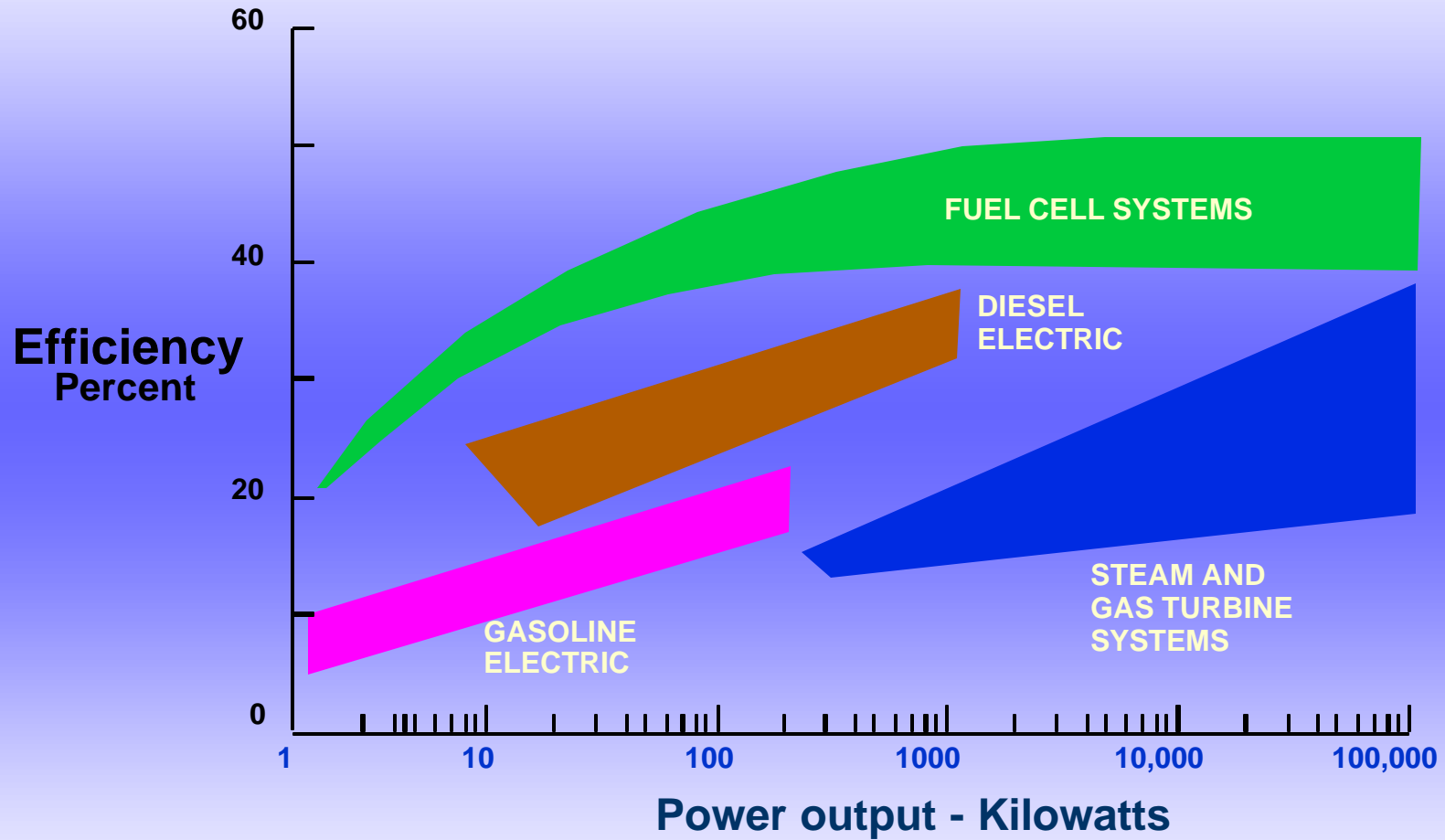
Protons and electrons combine with oxygen to form water, generating heat as a byproduct



## PEM Process Schematic

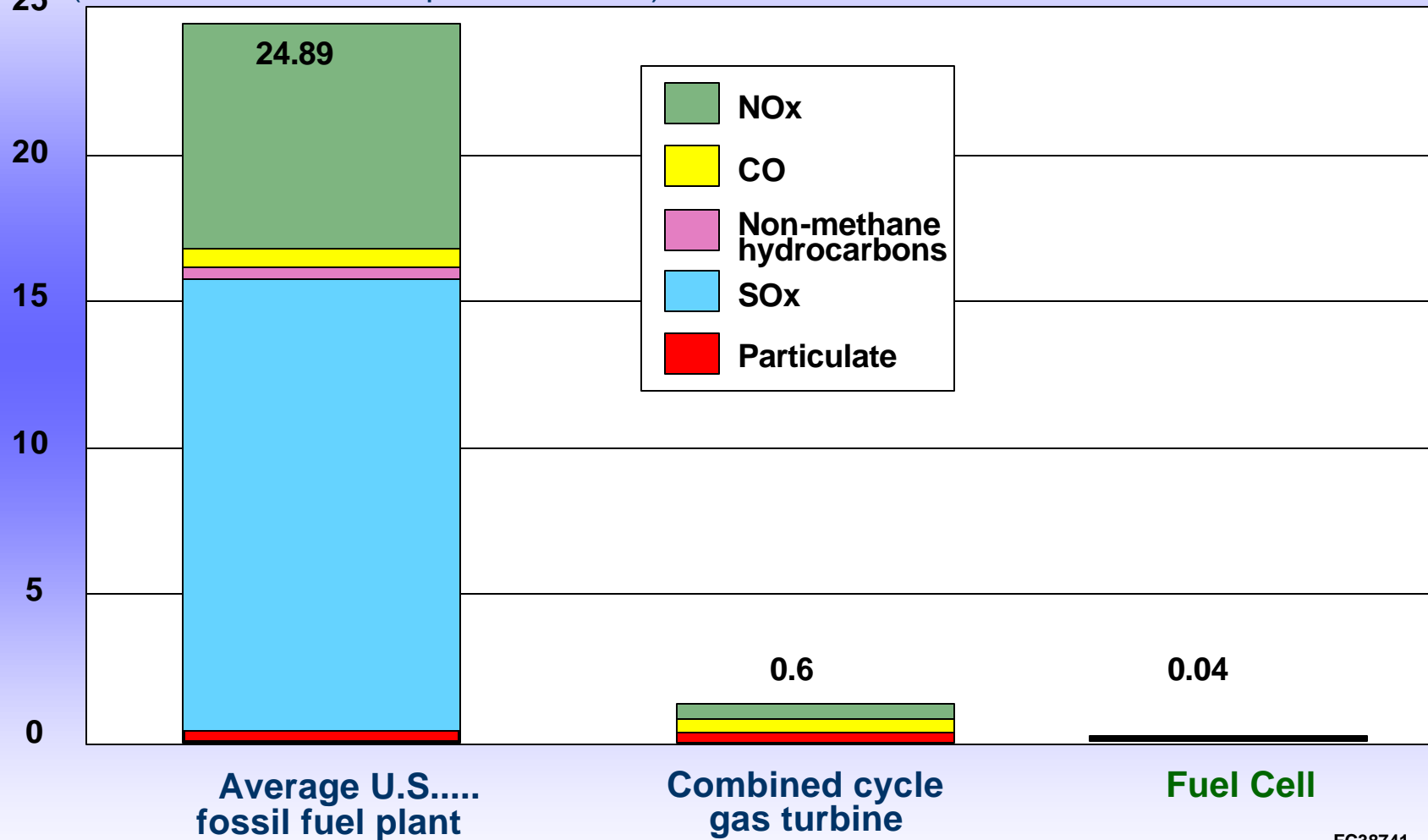


## Comparative Efficiencies



## Clean Emissions

(Pounds of emissions per 1000 kWh)





GE HomeGen 7000 7kW Unit



*GE MicroGen*

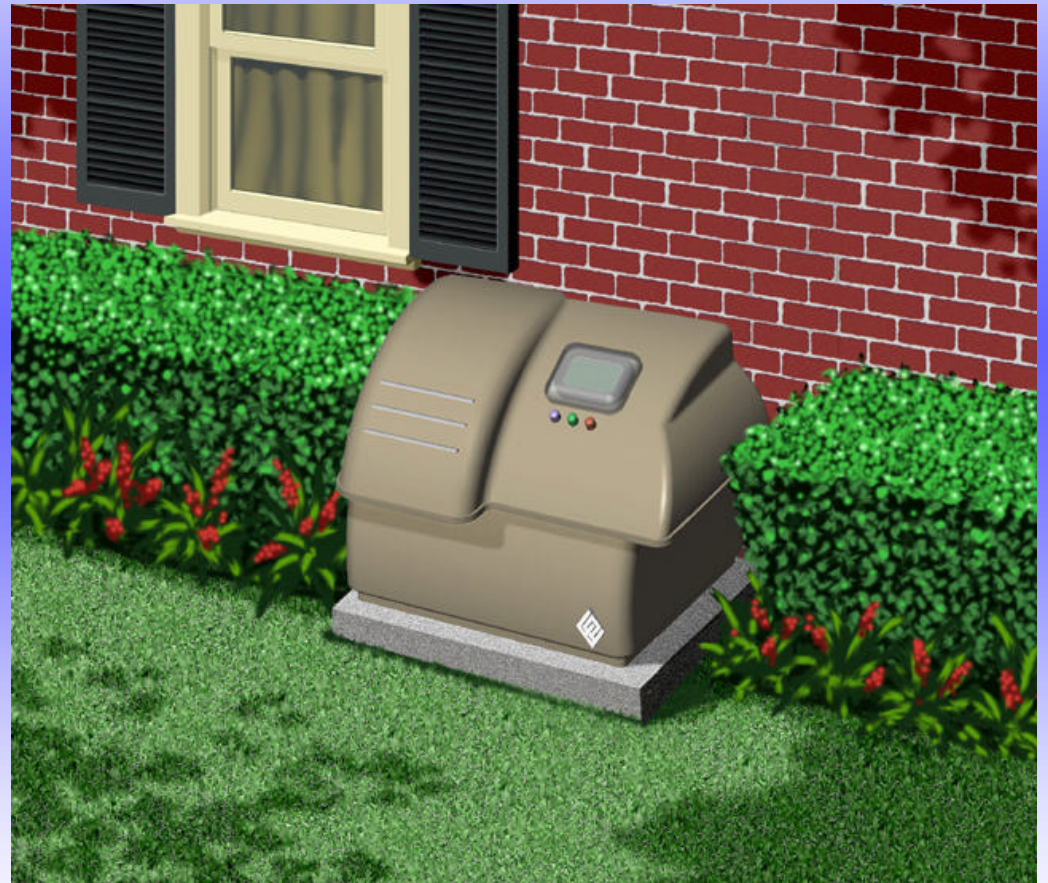
NW Residential Fuel Cell Unit



H Power Residential Unit



Energy Partners 3 kW Residential Unit



## GE HomeGen 7000 Specifications

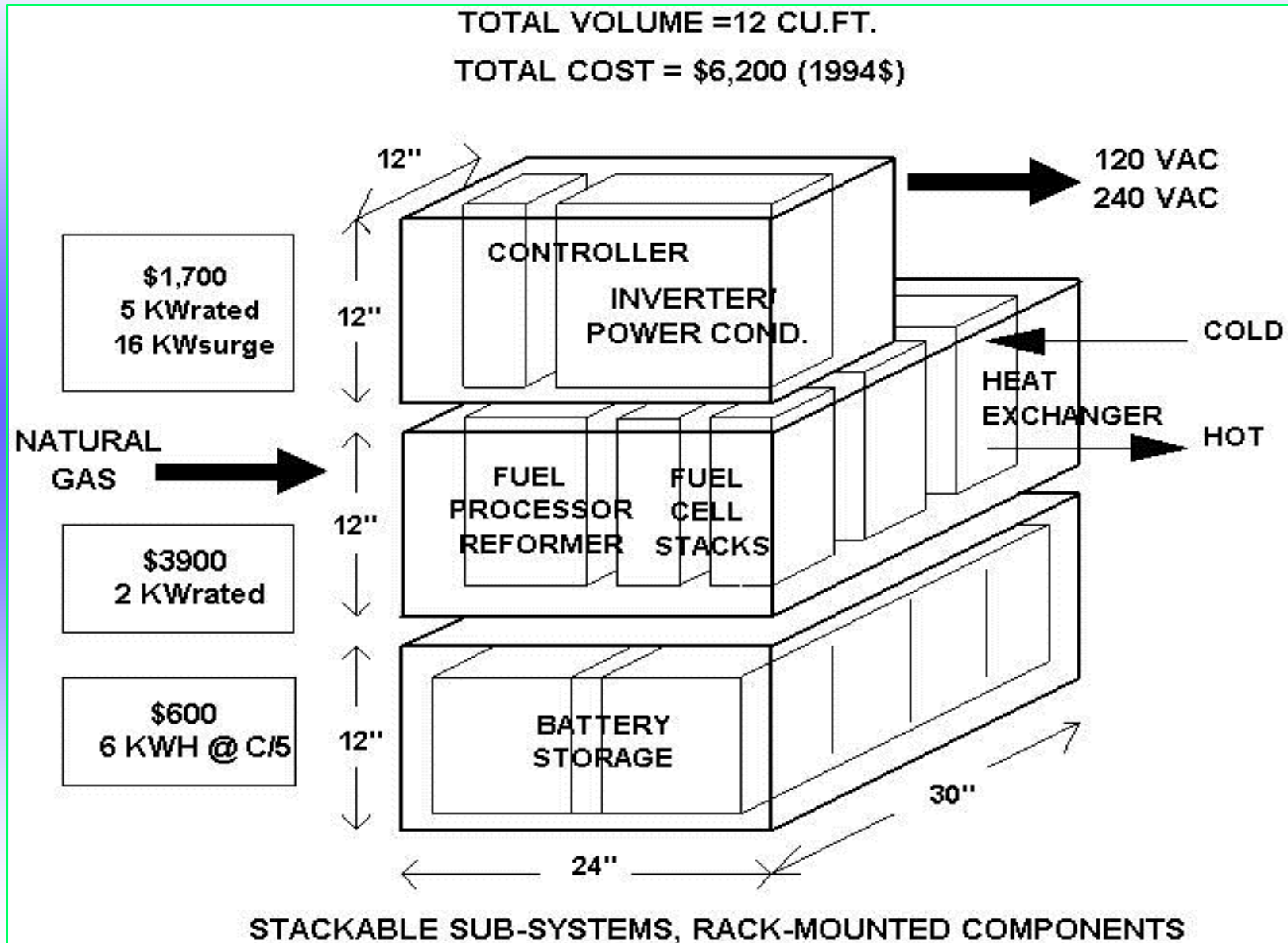
Physical Characteristics		Emissions	
<b>Size</b>	48" (Length) X 28" (Width) X 42" (Height)		NOx < 1ppm
<b>Weight</b>	<1,000 lbs		SOx < 1ppm
<b>Enclosure</b>	Fully enclosed, suitable for outdoor installation		CO < 1ppm
Ratings/Performance		Operating Conditions	
<b>Output*</b>	7 kW continuous 10 kW for 30 minutes 15 kW for 0.5 seconds	Temperature	-20° F to 104° F (standard) -40° F to 120° F (with optional upgrade)
* Rated at 1.0 power factor, 77° F, 500 feet elevation		Elevation	Up to 6,000 feet (standard) > 6,000 feet (with optional upgrade)
<b>Voltage</b>	120/240 VAC @ 60 Hz 115/230 VAC @ 50 Hz	Operating Characteristics	
<b>Systems Performance</b>		<b>Fuel</b>	
Simple Cycle Efficiency	40% @ 2 kW output 29% @ 7 kW output	Type	Natural Gas LP Gas Methanol
Cogen Efficiency	> 75%	Supply Pressure	> 1/4 PSIG
Operating Temperature	160° F	<b>Maintenance Intervals</b>	
Exhaust Temperature	150° F	Routine	8,000 hours
Recoverable Waste Heat	0.8 kW <sub>th</sub> @ 2 kW <sub>e</sub> (2,730 BTU/hr) 6.6 kW <sub>th</sub> @ 7 kW <sub>e</sub> (22,500 BTU/hr)	Major Components	40,000 operating hours
<b>Power Quality</b>	IEEE 519 or better	<b>Design Life</b>	15 years
		<b>Noise</b>	< 65 dBa @ 1 meter

## NW Residential Fuel Cell Specifications

- Net Electric (continuous) 3 kW
- Net Thermal (continuous) 2.5 kW at 120°F
- Peak Electric 8 kW (for 1 hr)
- Fuel methanol
- Fuel Consumption 0.5 gal/hr at 3 kW
- Water consumption <10 gal/day
- Size (inches) 36(h)x43(w)x30(d)

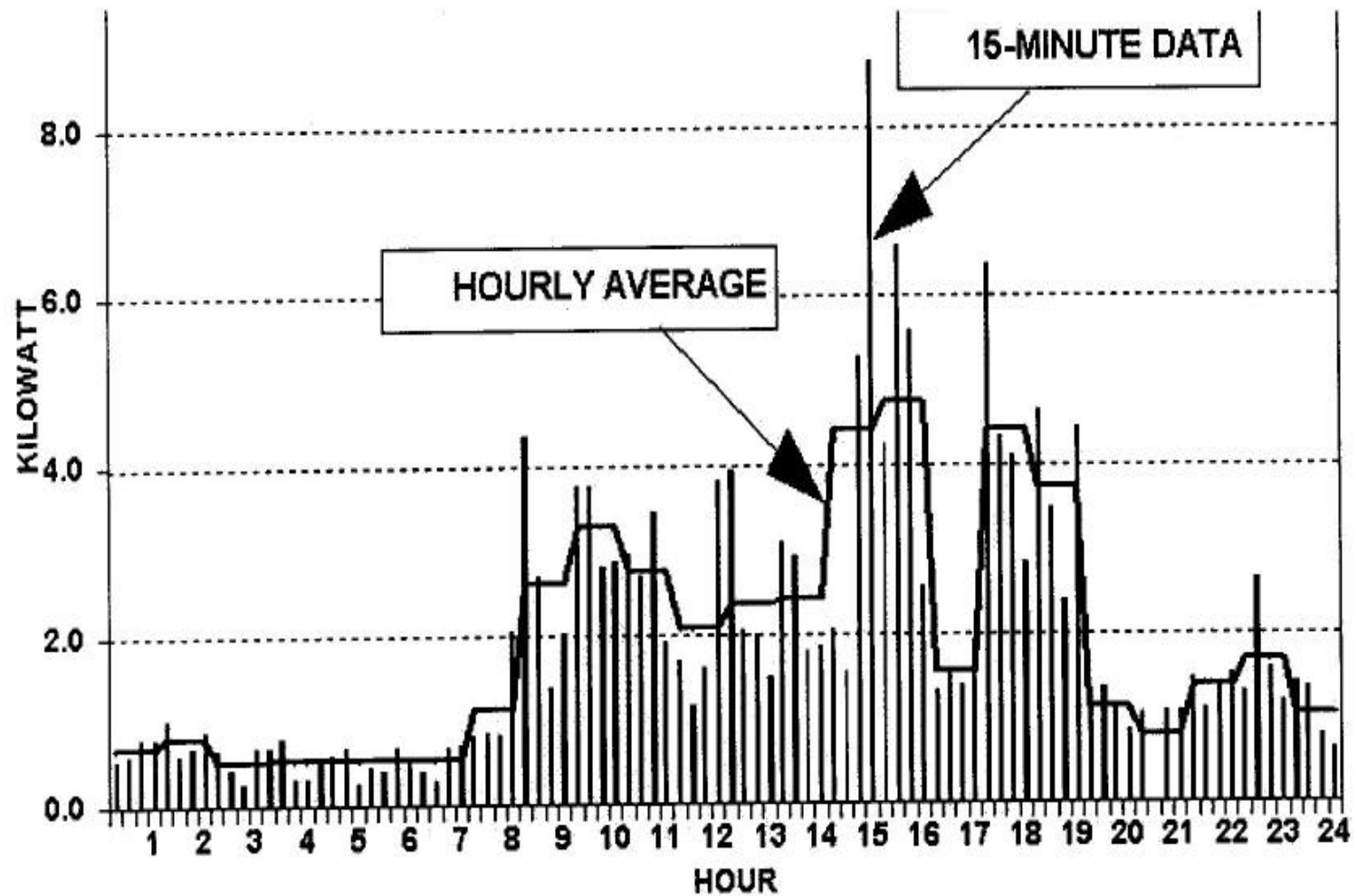


## Component Costs and Scaling 1995 \$\$





## US Hourly Average Load Vs 15-Minute Segments



## Estimated Commercialization Schedule

### Beta Test and Evaluation Units

- Manufacturing currently under way
- Beta testing units throughout 1999-2000

### Pre-Commercial Units

- Manufacturing begins 2nd Quarter 2001
- Several hundred testing units throughout 2000

### 3-7 kW Commercial Unit

- Units available third quarter 2001
- Estimated price \$??? try \$15,000

## Back of the Envelope

### Assumptions

3500 Sq. Ft Home, Gas & Electric Appliances

Fuel Cell Installed Cost                      **\$15,000**                      **\$8,000**

### Operating Data

### Operating Costs

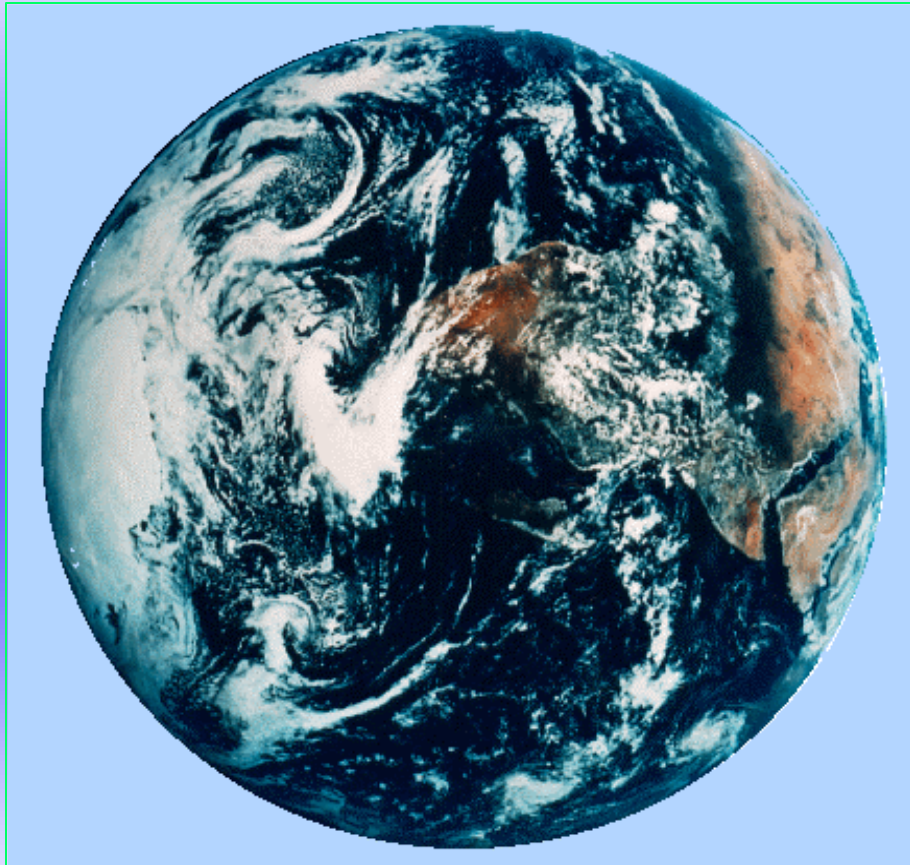
Average Hourly Consumption	2 kWh	
Annual KWh	16,435 kWh	
Gas Cost	<b>\$5.00</b> MCF	\$1,027 Yr.
Annual Maintenance	8 Hrs	\$520 Yr.
20 Year Amortization	\$1,500 Yr.	\$750 Yr.
Waste Heat Available @ 7kW	0.22 mmBtuH	
Est. Waste Heat Recovery	45 %	<b>(\$626) Yr.</b>

Total Annual Cost	\$2,421	\$1,671
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Fuel Cell Energy Cost	\$0.15 kWh	\$0.10 kWh
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## Summary

1. Significant capital invested in PEM residential fuel cell programs.
2. Unproven PEM reformer technology, unknown PEM stack longevity.
3. “Beta” testing/performance evaluation by seven manufacturers in 2000-2001.
4. Commercial products forecast for 3rd. quarter 2001 market entry.
4. Sales channels illusive.
5. Unit pricing dependent on mass production.
6. Performance pricing dependent on local conditions.
7. Consumer acceptance dependent on 5 & 6 plus reliability.
8. Early Fuel Cell power estimated \$0.15/kWh. Not including reserve for stack replacement. Heat recovery essential to valuation.
9. Product reliability key. That’s what consumer’s will buy.



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Power It Wisely!

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*The Wise Power Choice*  
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